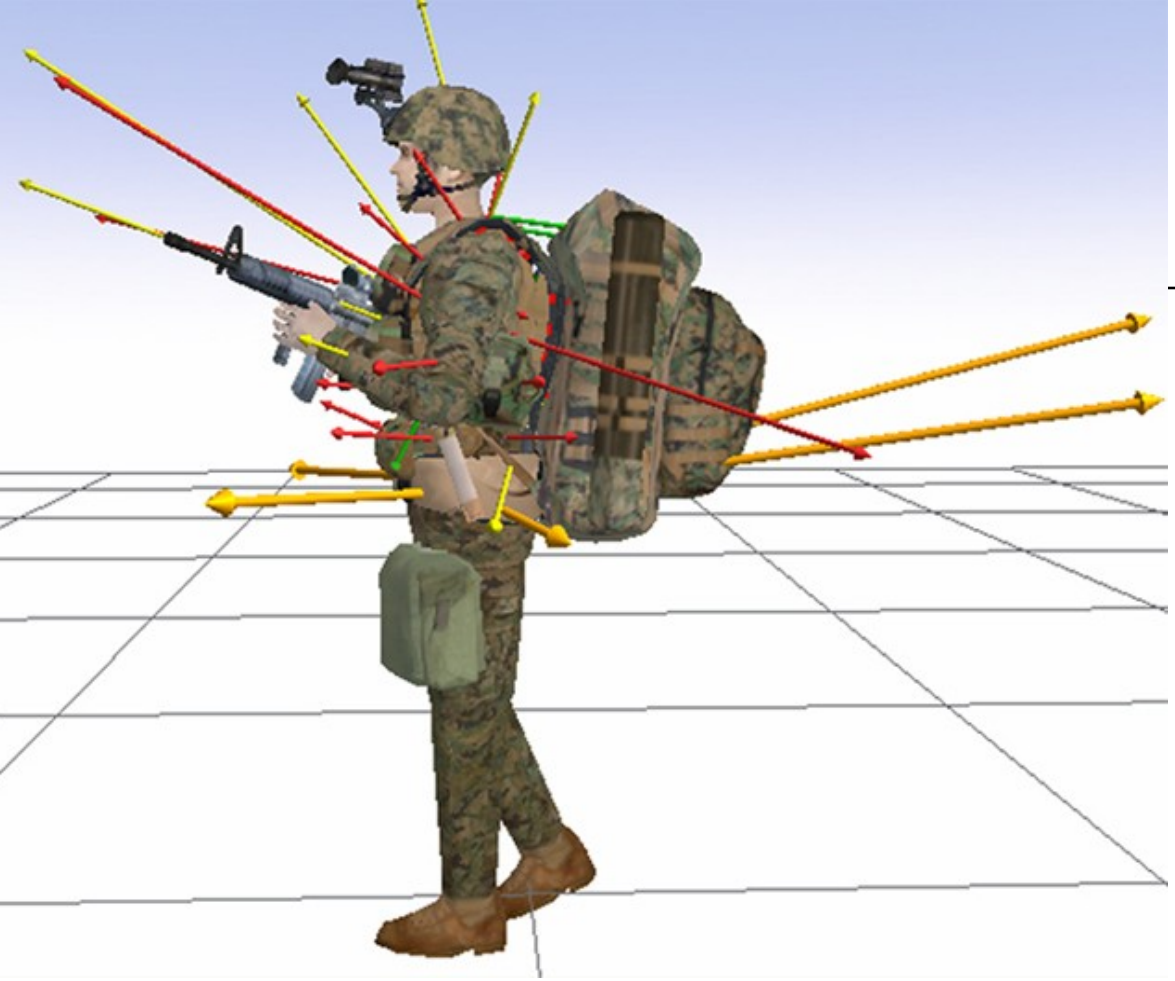

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Robert Playter, PhD
Mike LaFiandra, PhD
Nancy Cornelius, PhD
Shervin Talebi, MS
Antonio Layon, MS
Binh Nguyen

Virtual Prototyping of the Soldier System

Digital Biomechanics

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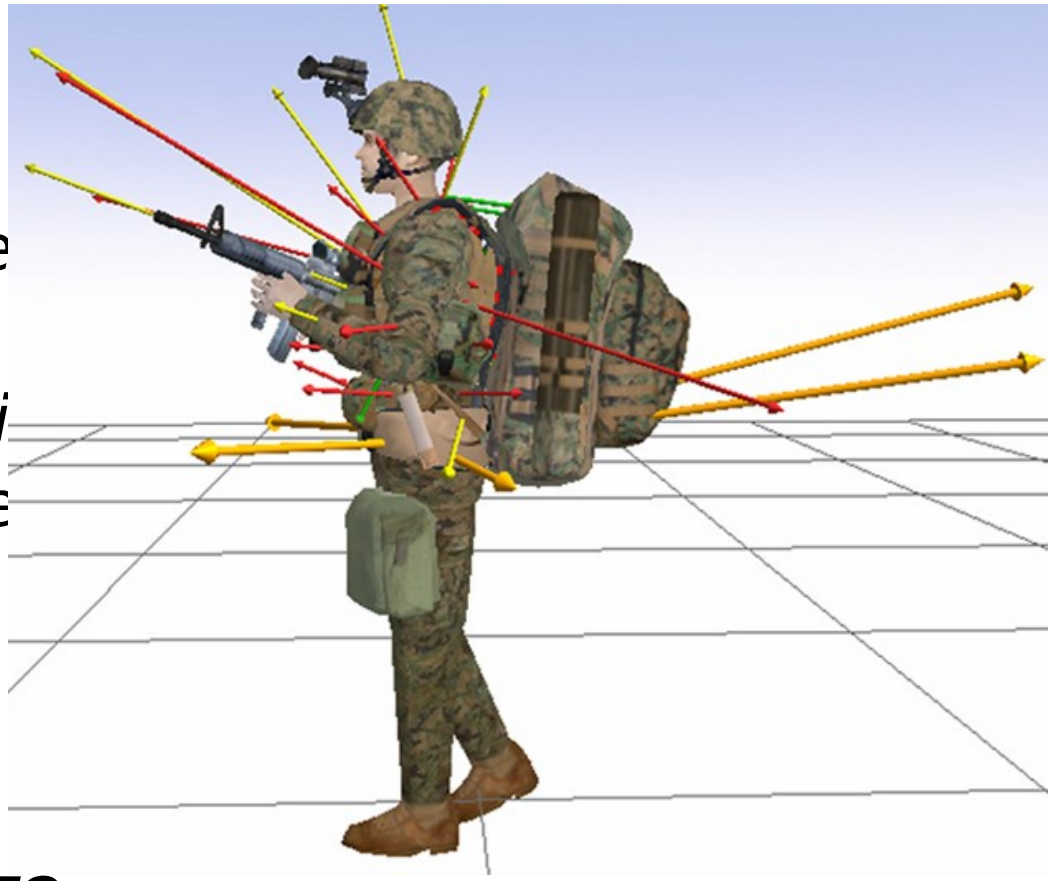
Virtual prototyping of soldier system performance

Features:

- *Accurate human mode*
- *Equipment models*
- *Physics-based simulati*
- *Virtual obstacle course*
- *Validation*



Development led by:

- ***SBIR Phase I, II, II Plus***
- ***Light Weight Soldier STO***

Human Models

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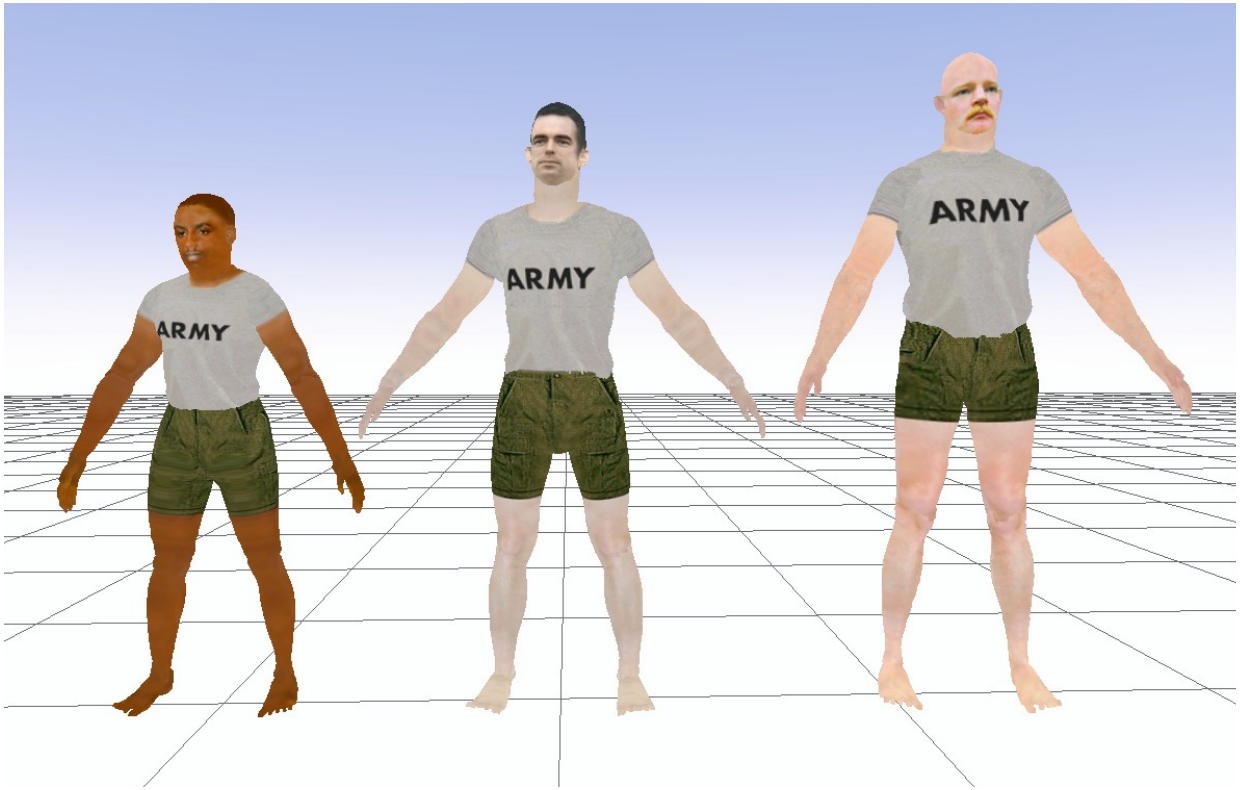
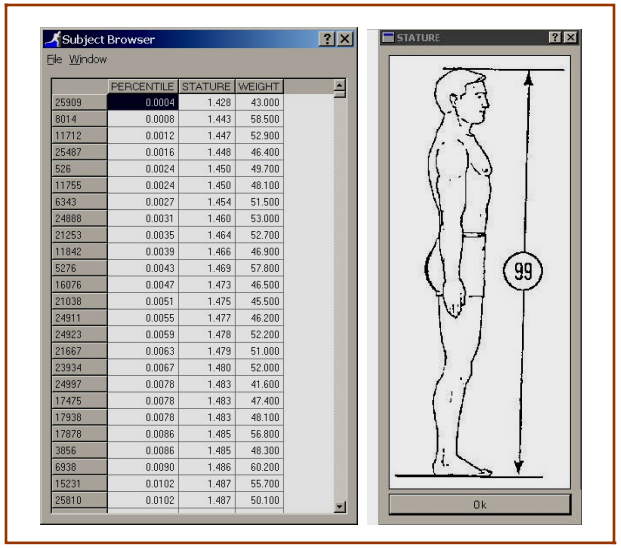
- Key anthropometric dimensions for body armor and load carriage design (Gordon, Corner).
- 1988 Army Anthropometric Survey Database





Anthropometric Database

Equipment Models

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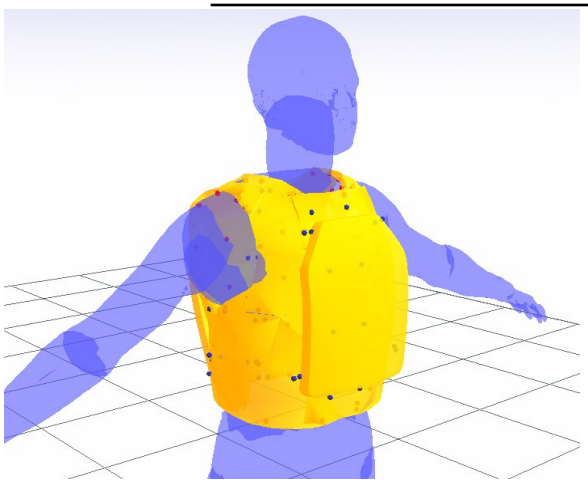
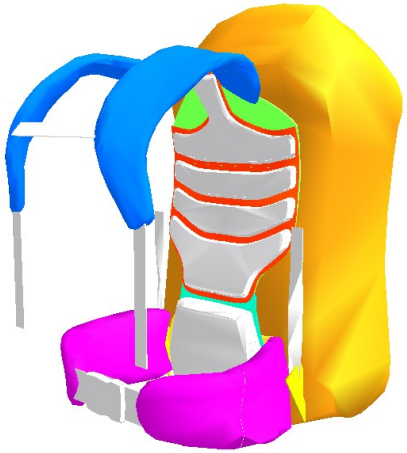


Interceptor Body Armor & SAPI Plate

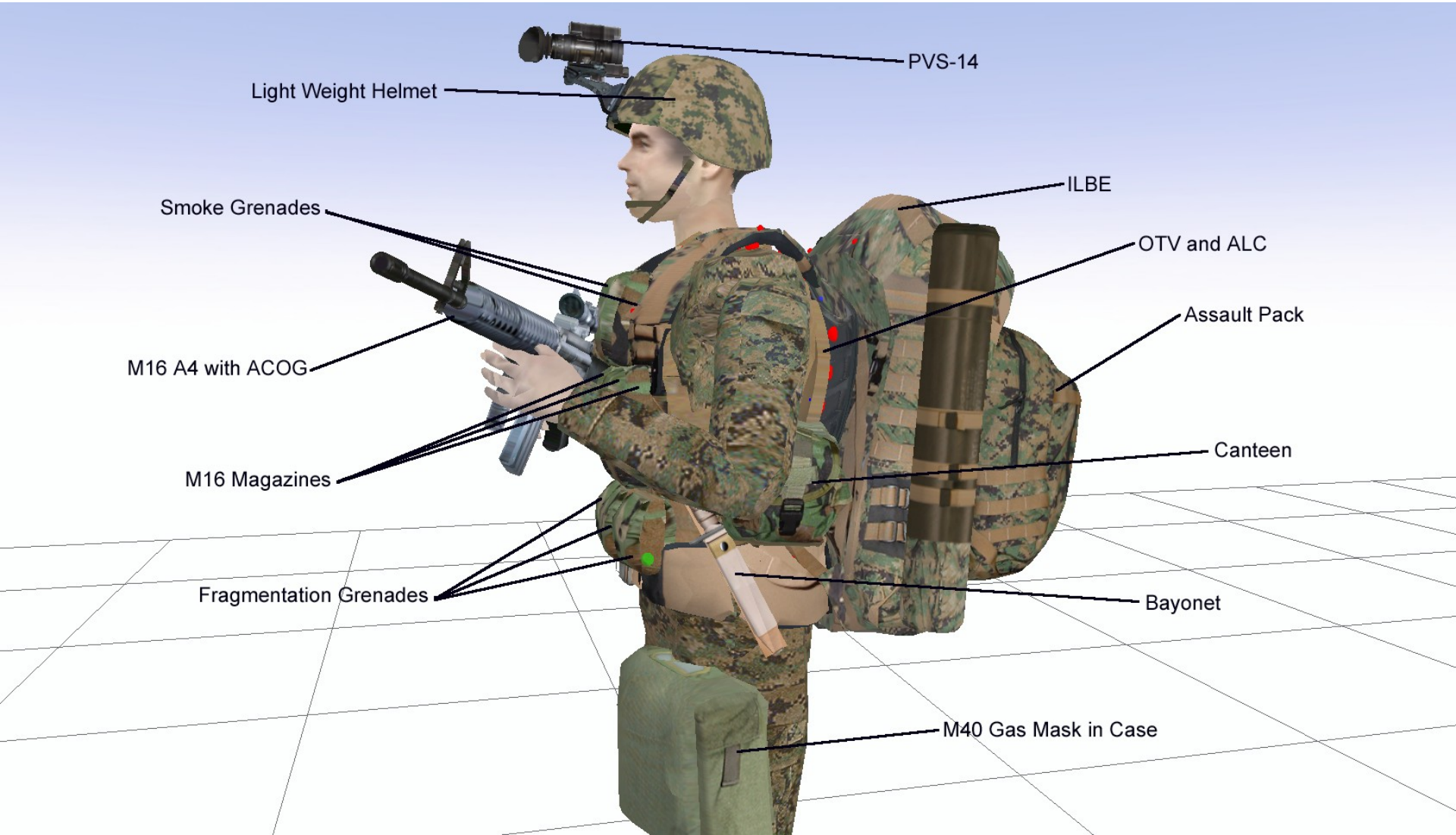
Includes mass properties, shape, and material properties



Integrated Load Bearing Equipment

Future Force Warrior

MERS Rifleman



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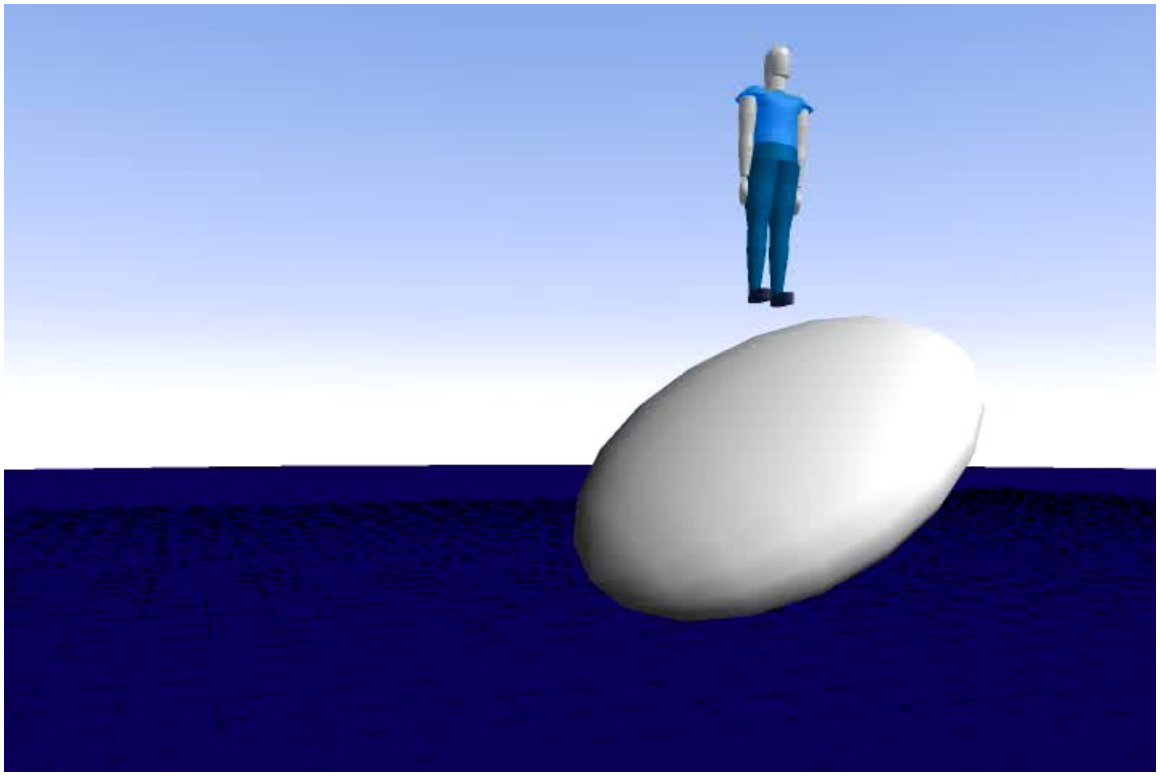
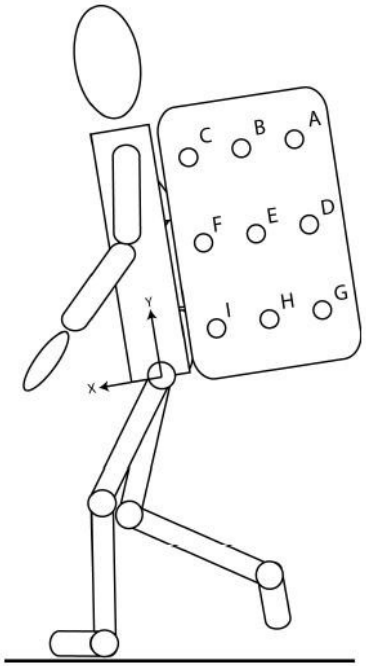
Physics-Based Simulation

- Standard techniques for simulating physical laws
  - Newton's 2nd law: $Force = mass * acceleration$
  - Gravity
  - Collision
  - Friction
- Sensors
- Muscles
- Environment
  - Vehicles
  - Terrain



Validation

BostonDynamics



Pack Properties:

Total Mass = 34.09 kg

Nine COM locations

Measures:

Lean angle

Joint kinematics

Ground Reaction Forces

*** Report provided by the Military Performance Division / U.S. Army Research Institute of Environmental Medicine**

Applications to Soldier Modernization Programs

BostonDynamics

Marine Corps Expeditionary Rifle Squad Future Force Warrior

Boston Dynamics

Reach Tests

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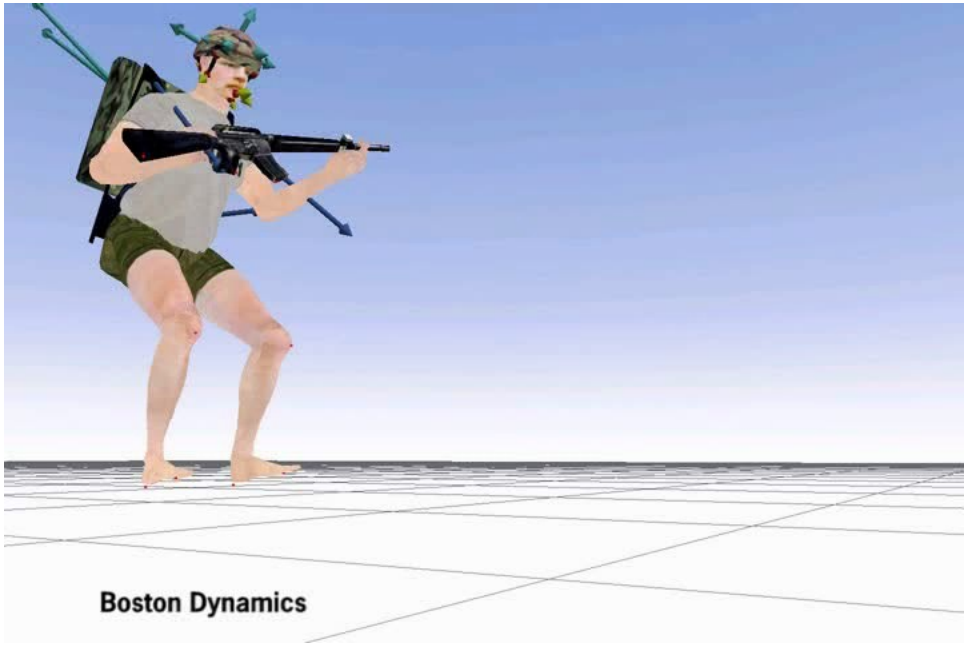
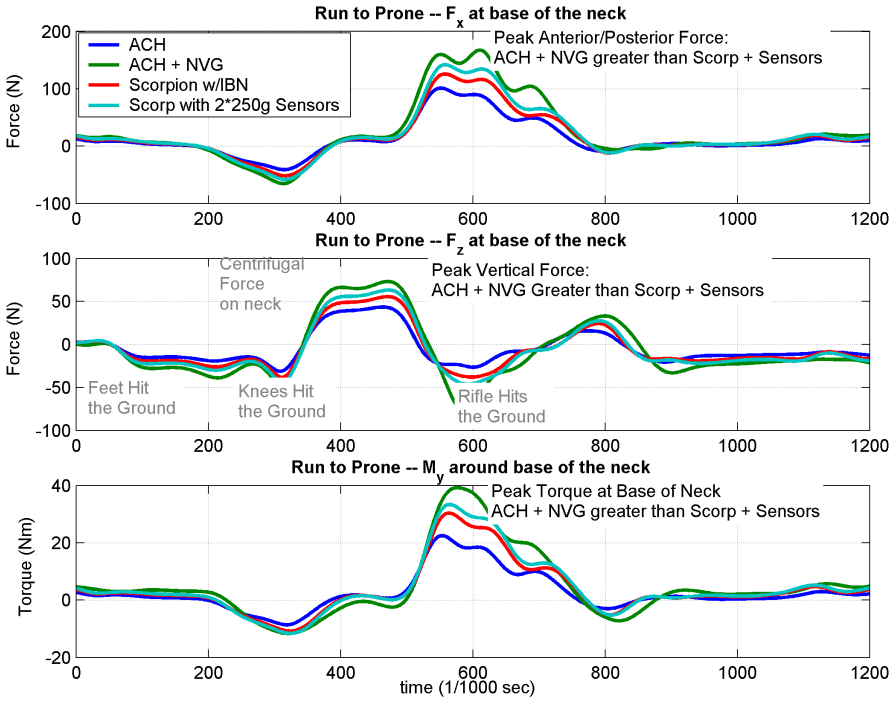
Analyze interference during realistic tasks

Neck Loading & Safety

Analyze forces not accessible in live subject studies?



Neck Forces during dive-to-prone for 4 different helmet designs



Live Data Collection

- Dive to Prone
  - With and Without PVS14
- Jump to Stand
  - With and Without PVS14

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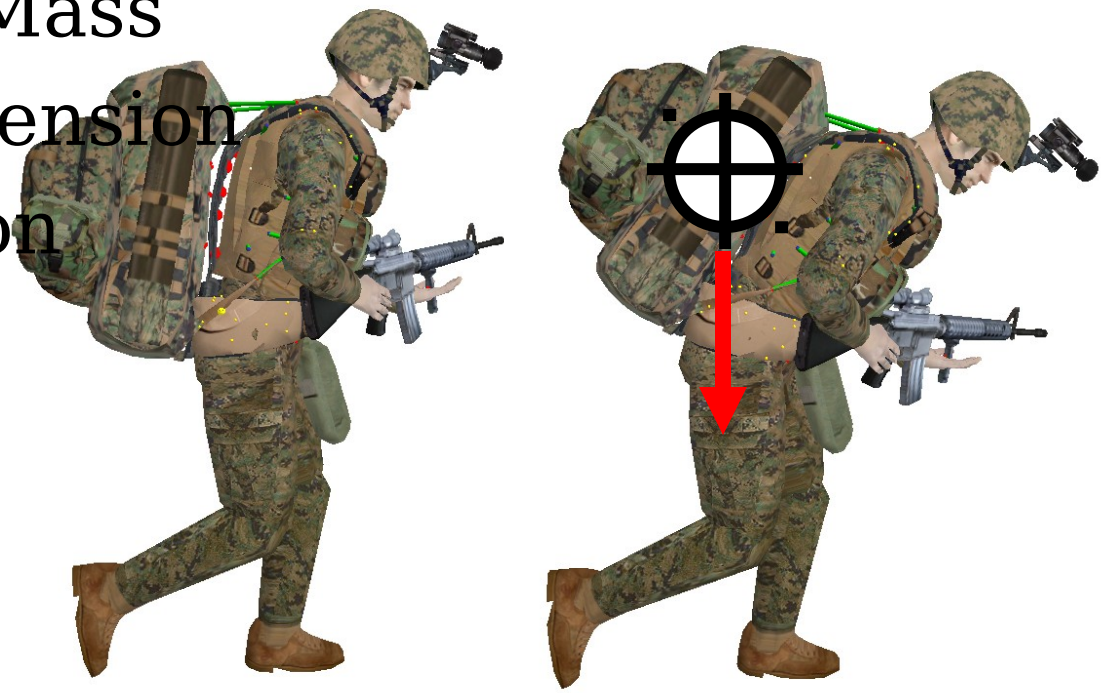
Load Carriage Analysis

Percentage of carried load is transferred to the hips

Key parameters:

- Load Center of Mass
- Shoulder strap tension
- Belt configuration
- Soldier posture



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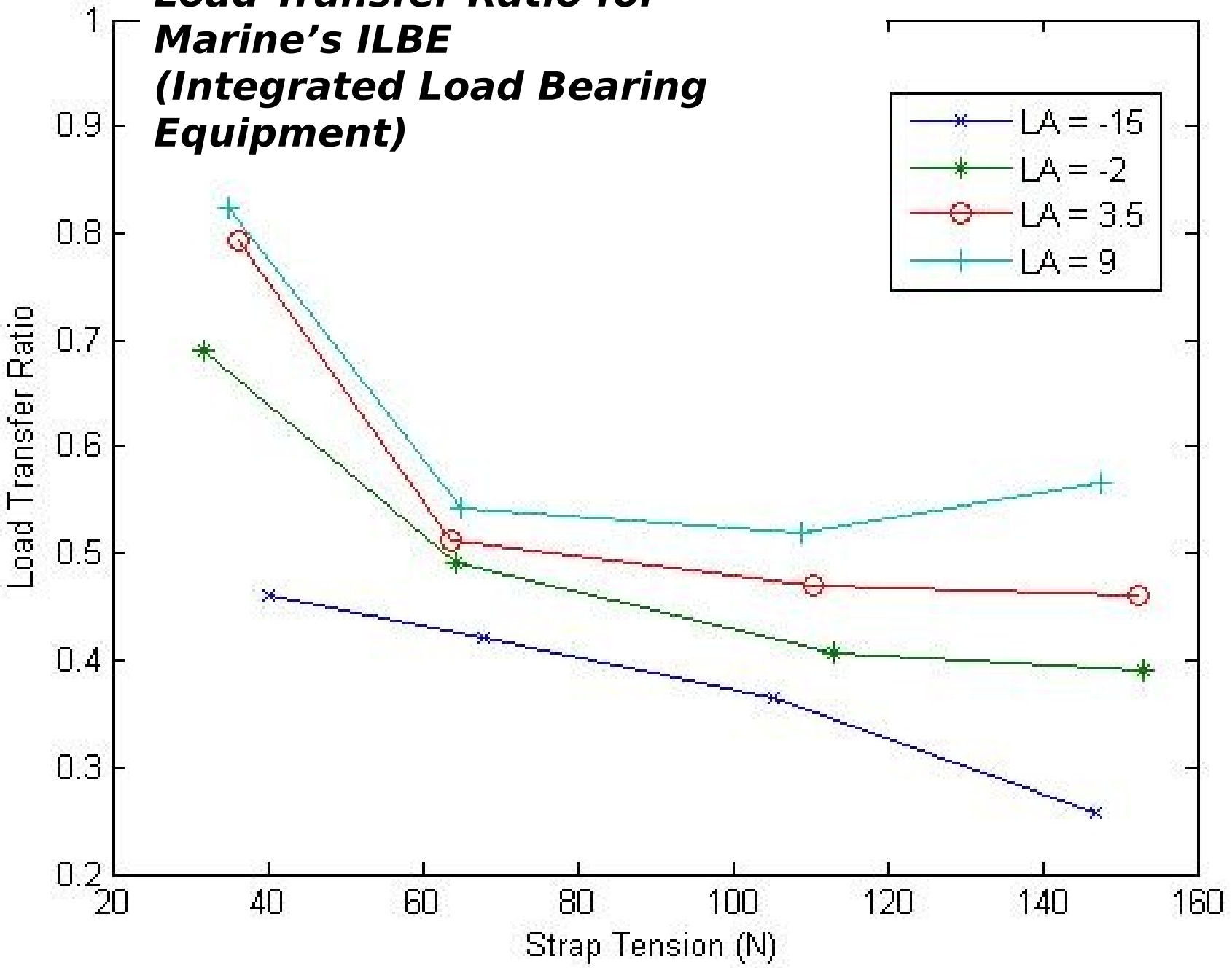
Load Carriage Simulations


Load Transfer Ratio for Marine's ILBE (Integrated Load Bearing Equipment)
LA = -15
LA = -2
LA = 3.5
LA = 9
Load Transfer Ratio
Strap Tension (N)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
20
40
60
80
100
120
140
160

Future Force Warrior Ensemble

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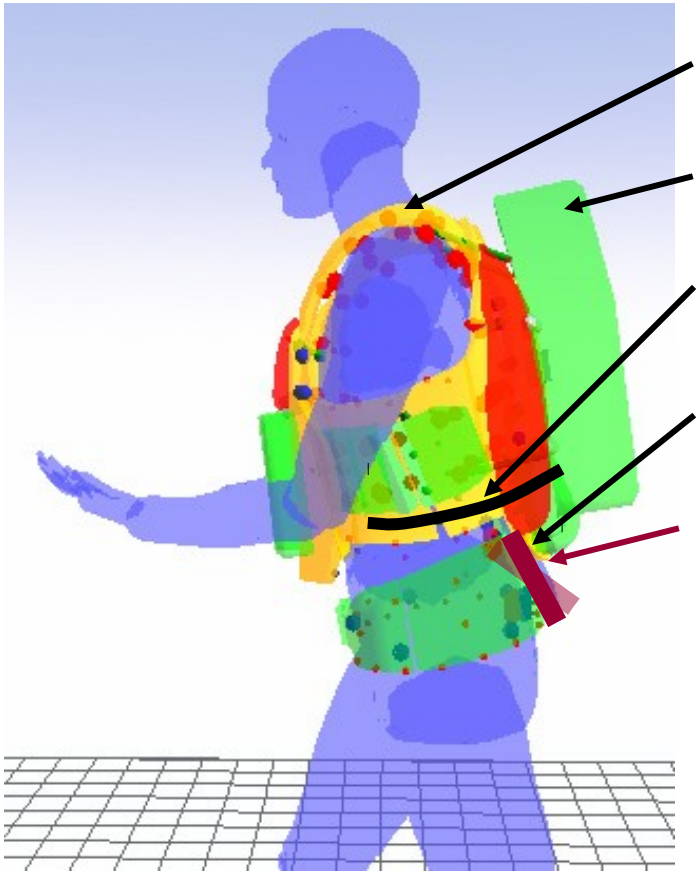
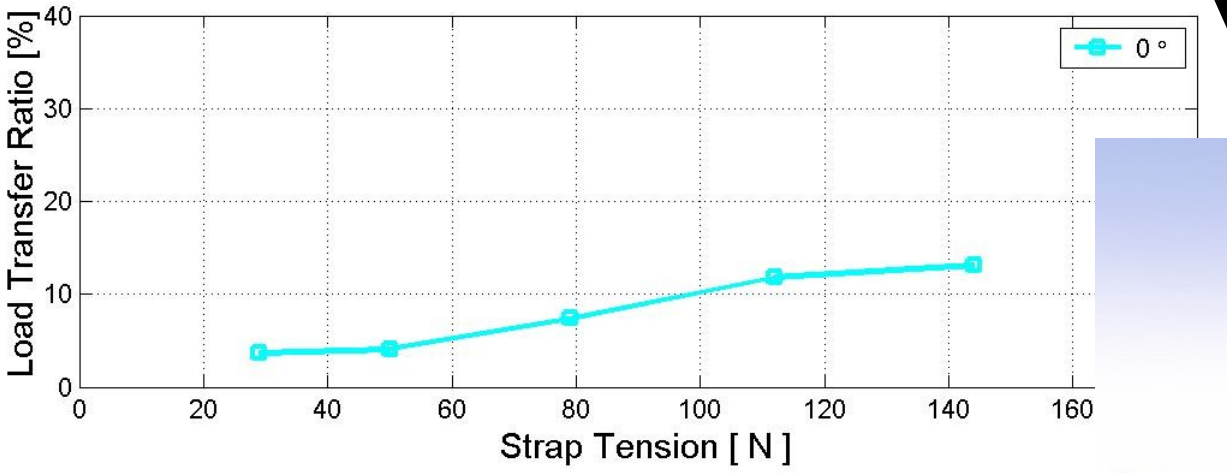
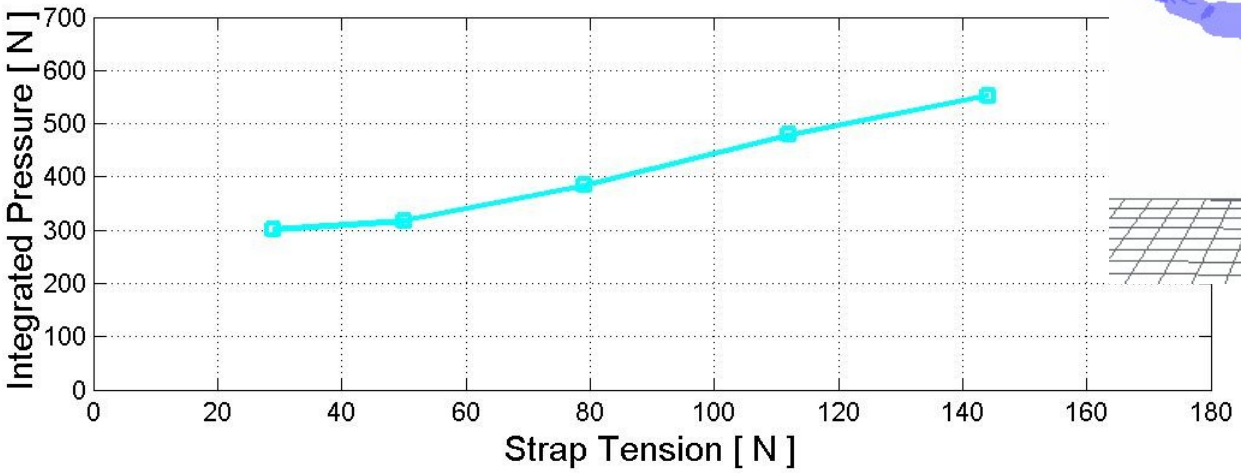
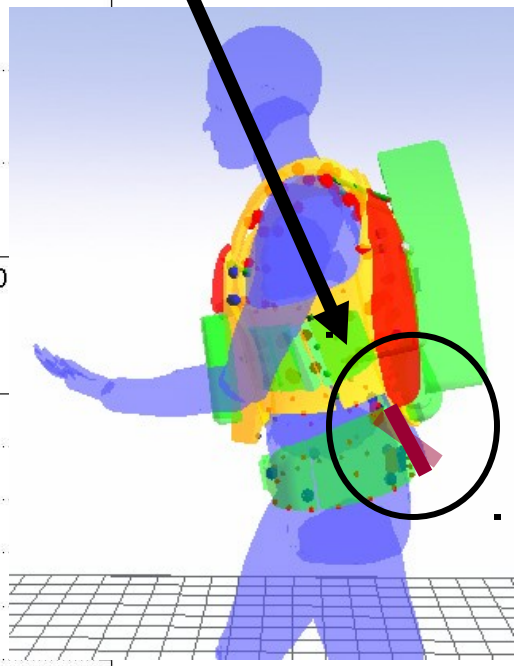


- Compliance
- Load
- Strap Tension
- Friction
- “Ballistic Belt Angle”

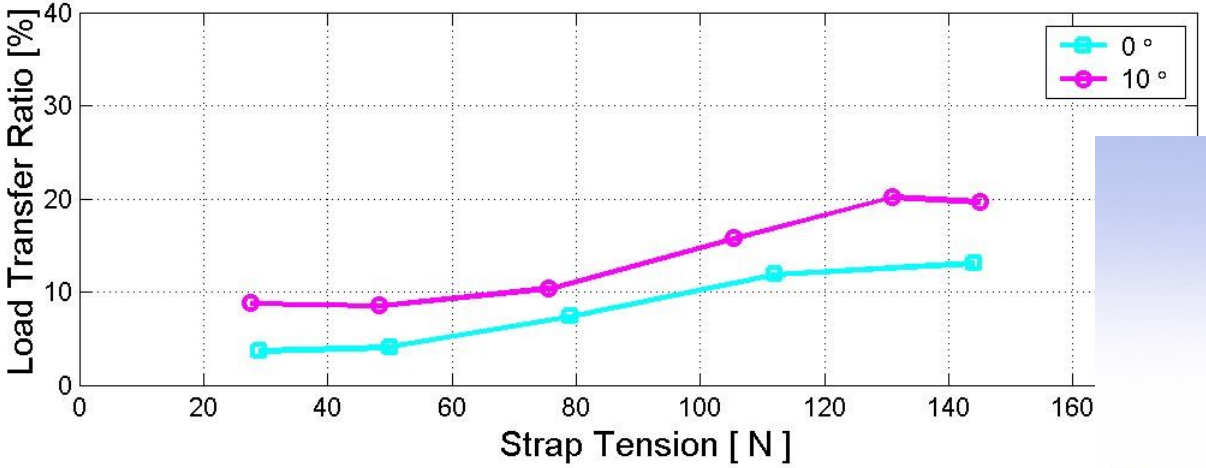
Effect of 'Ballistic Belt Angle'

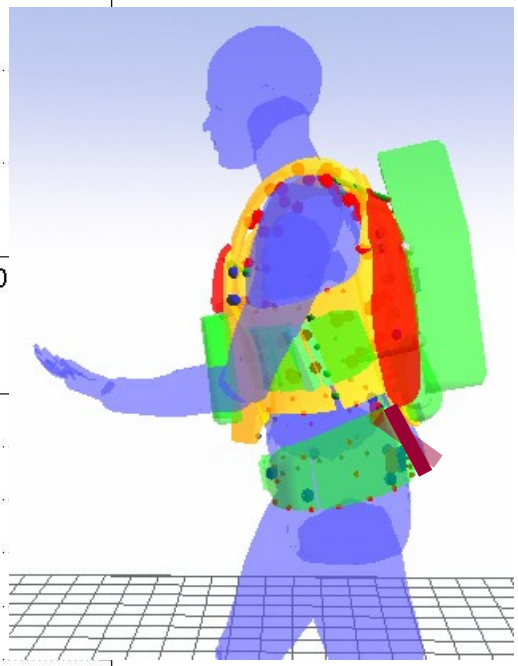


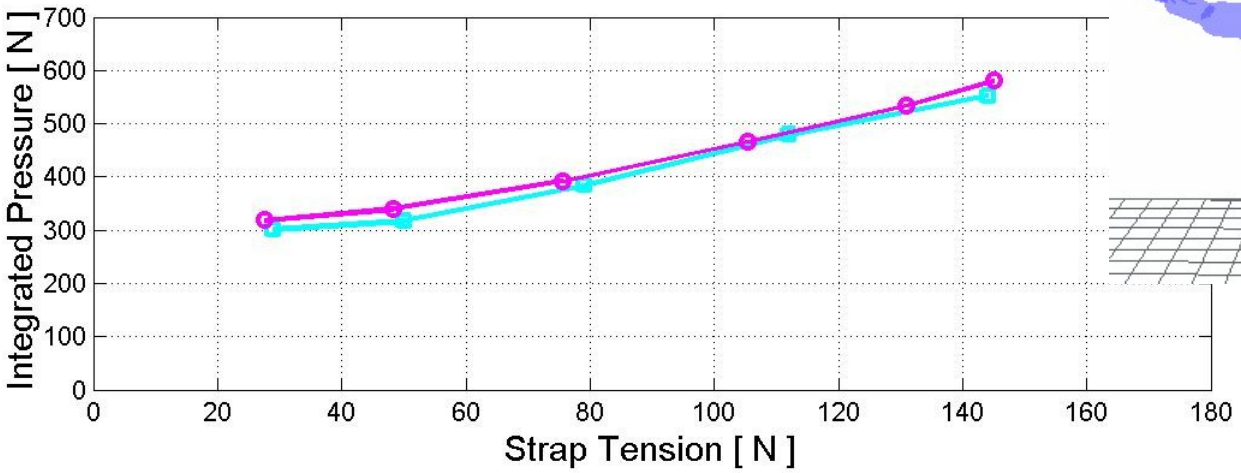




Effect of 'Ballistic Belt Angle'







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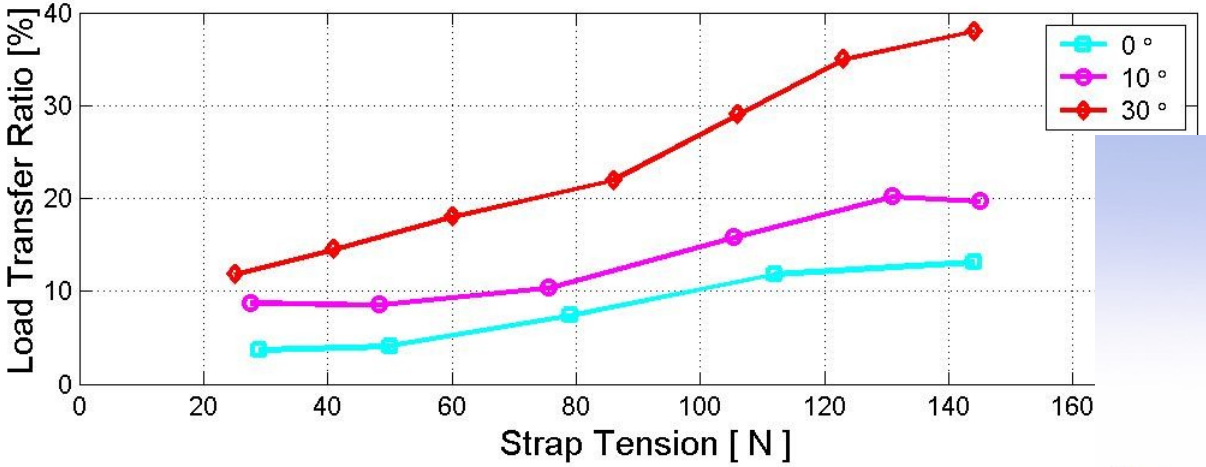
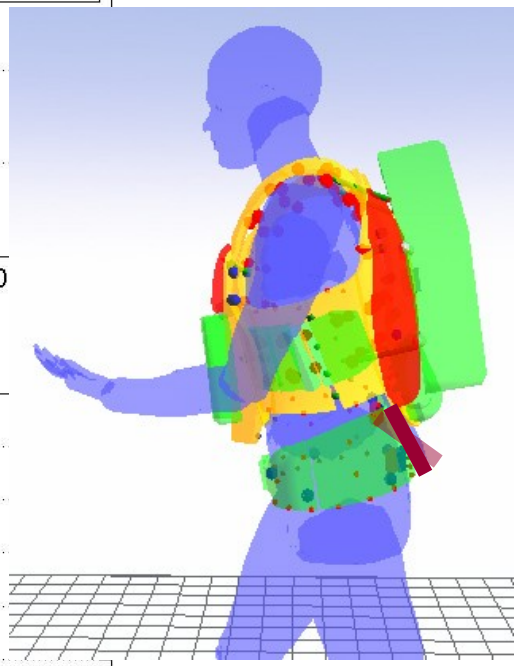
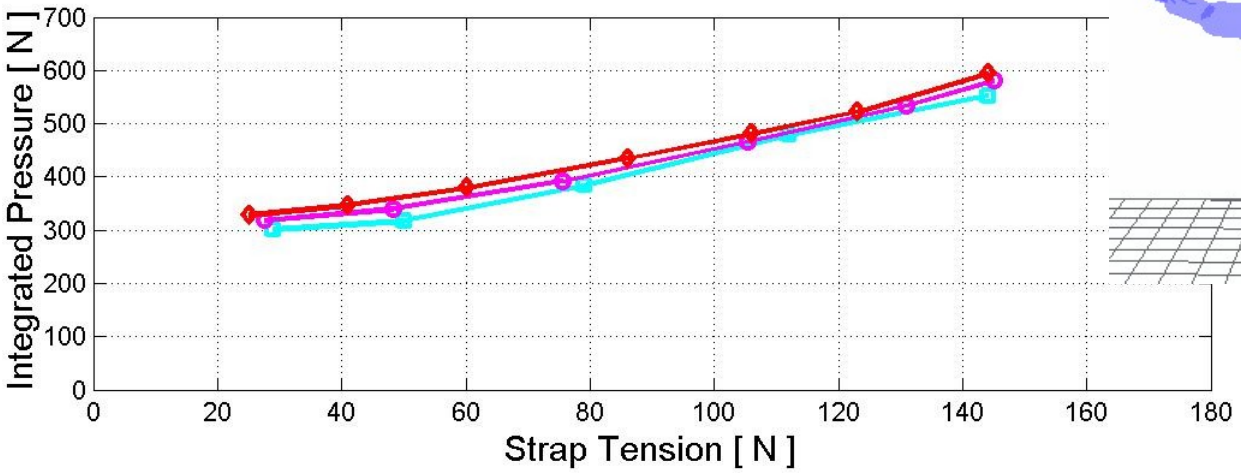
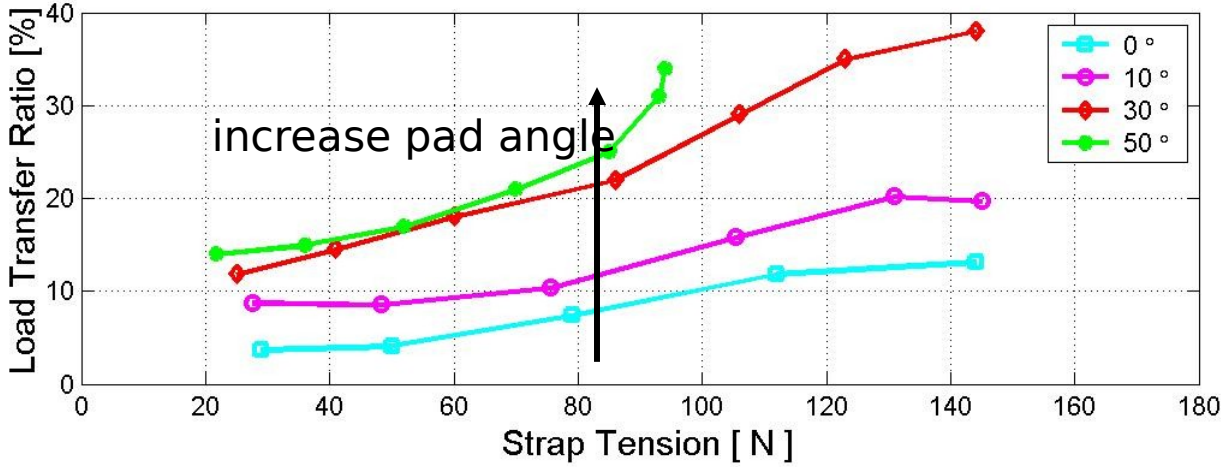
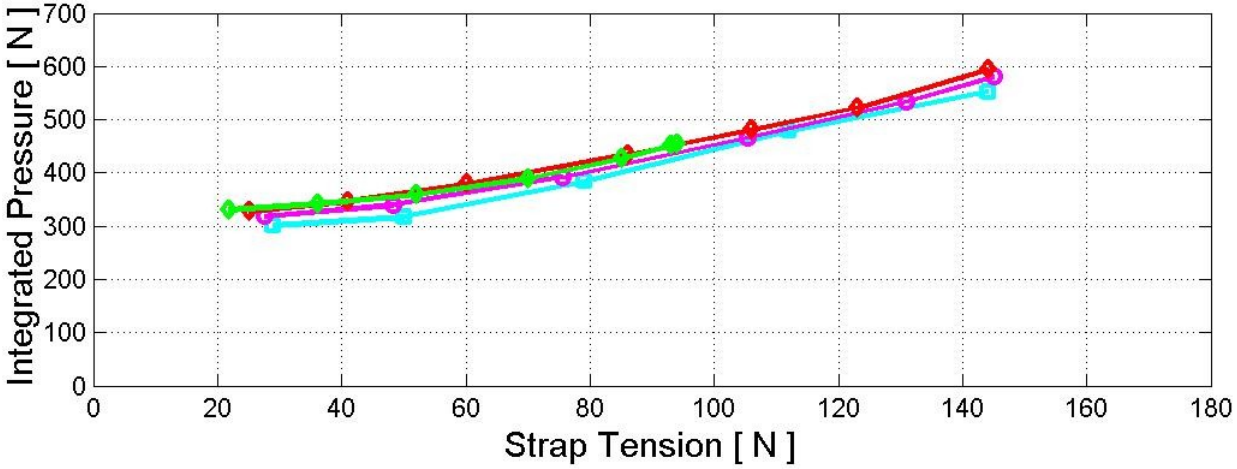






Effect of 'Ballistic Belt Angle'





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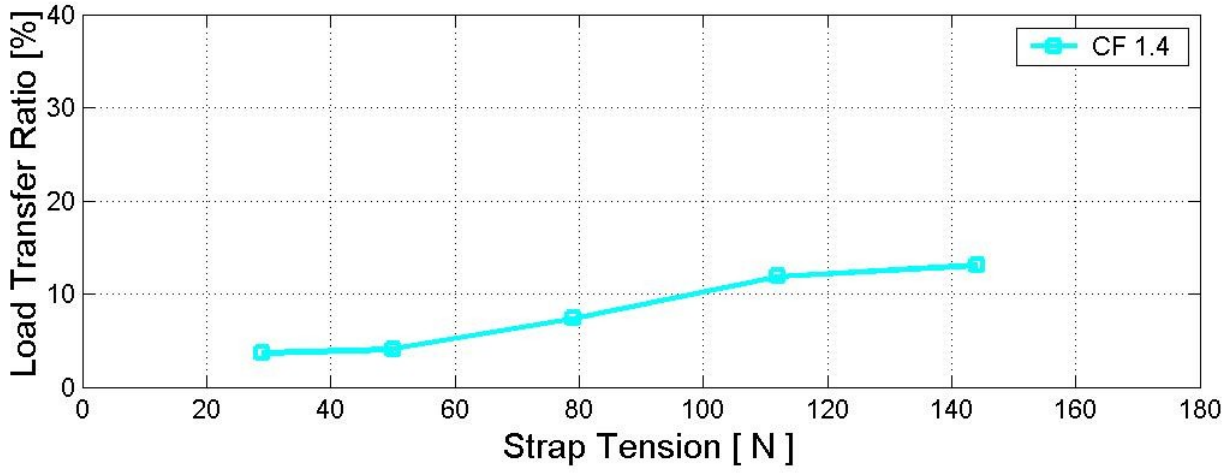
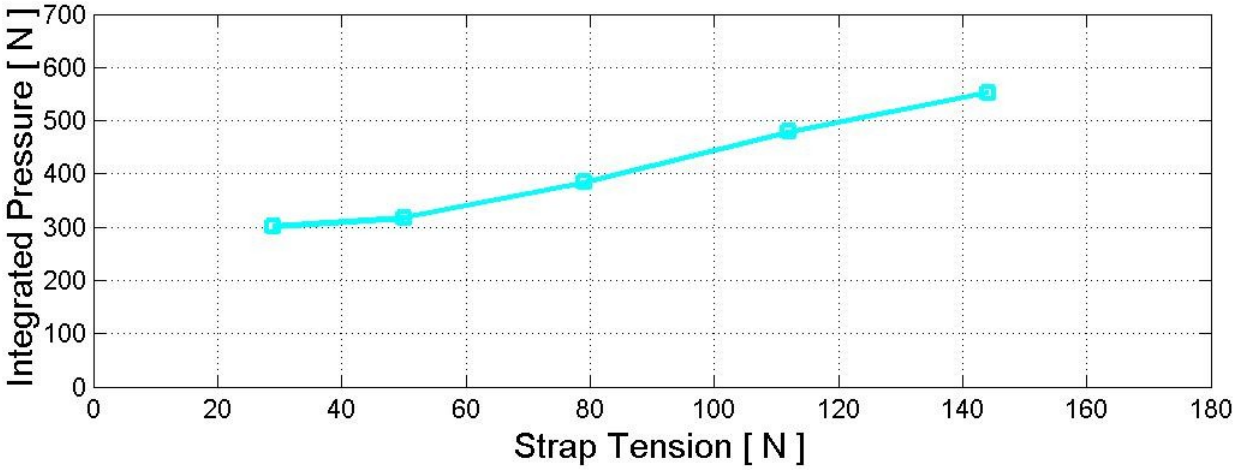
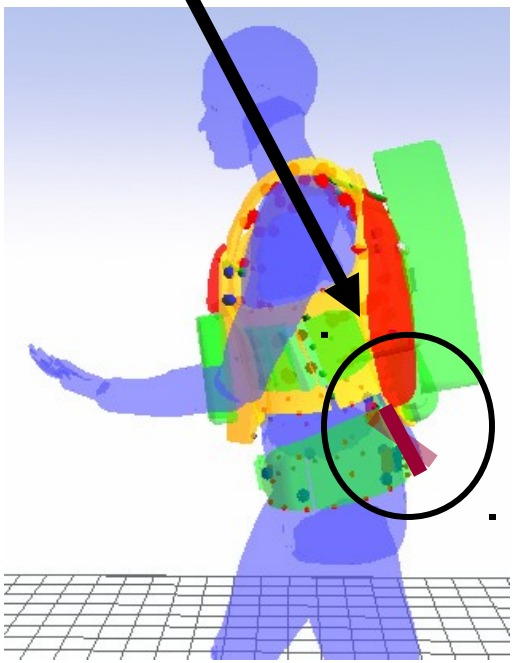
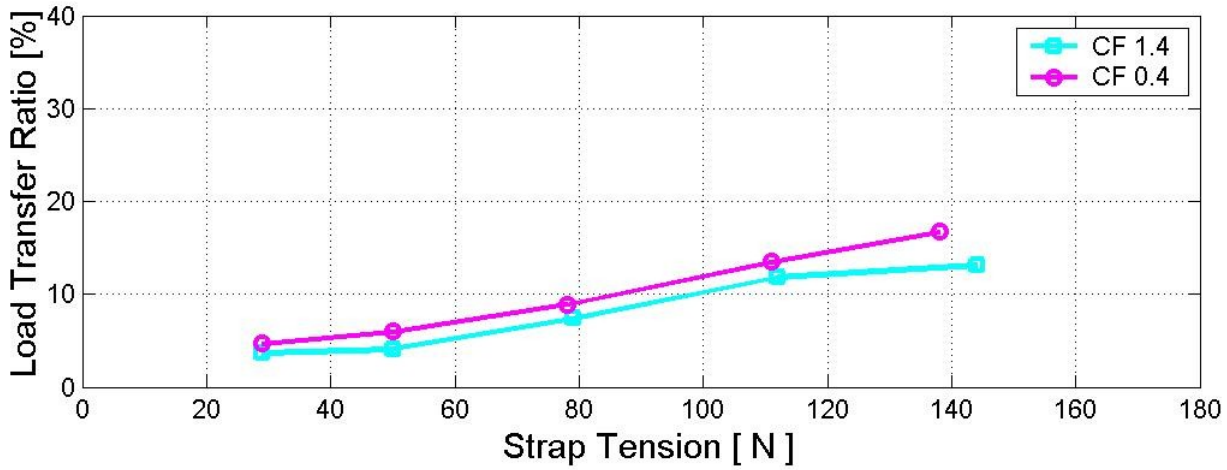
Effect of 'Ballistic Belt Friction'

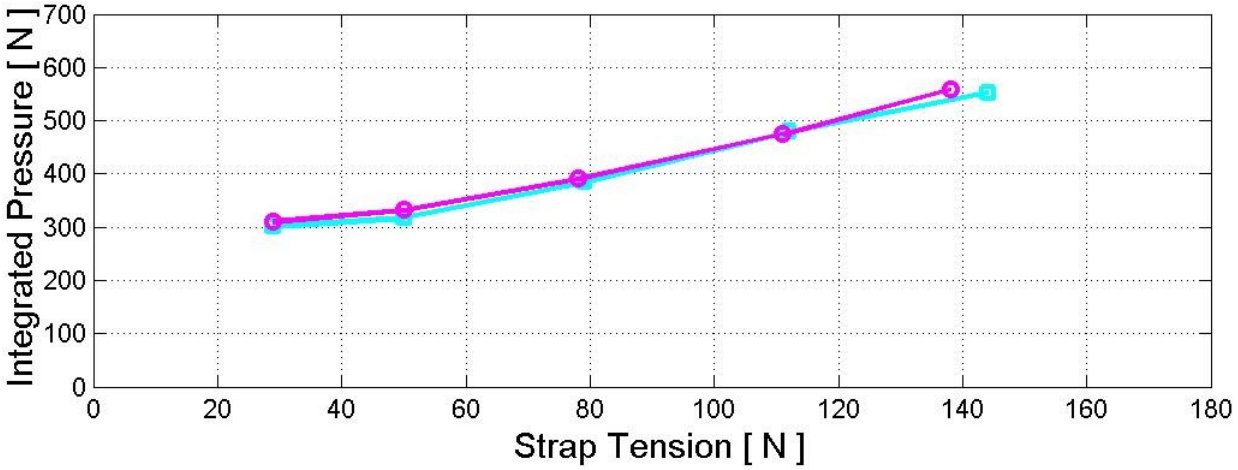


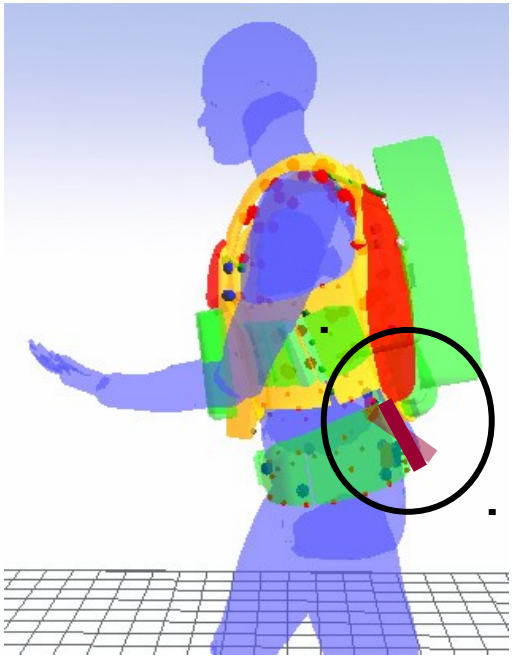




Effect of 'Ballistic Belt Friction'







Summary

- Advantages of dynamic simulation
  - Superior access to force data
  - Repeatable, controlled environement
  - Safe
- The percentage of carried load shifted to the hip increases with
  - Positive belt connection versus passive connection
  - Decreasing shoulder strap tension
  - Forward lean angle
- Hips belts “can be” effective for shifting weight to hips. Why don’t soldiers use them?
  - Do they reduce mobility
  - Improper belt integration?

REUTERS PHOTO/CAREN FIROUZ

End
Thank You

Contact Information:
Boston Dynamics
515 Mass Ave
Cambridge MA 02139
617-868-5600
www.BostonDynamics.com
playter@BostonDynamics.com